Abundance and Composition of Sheefish in the Kobuk River, 1996

by

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Alaska Department of Fish and Game   **Division of Sport Fish**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@

Compass directions:

east	E
north	N
south	S
west	W
Copyright	©

Corporate suffixes:

Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2 etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_0
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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ABSTRACT

The goal of this study was to determine the stock status of spawning sheefish *Stenodus leucichthys* in the upper Kobuk River. The study objectives were to estimate abundance, and length and age composition of spawning sheefish in a 130 km reach of the upper Kobuk River and to estimate harvest of the subsistence gillnet fishery on Hotham Inlet. Sampling on the Kobuk River was conducted August 17 - September 22, 1996. Sheefish were collected by hook and line, and beach seine. Length, sex, and age data were collected and sheefish were marked with a Floy tag. Sheefish caught in the subsistence fishery were examined for tags and sampled for length, sex, and age data. Sheefish examined ranged from 8 to 22 years of age. The largest proportion of female sheefish was age 14 and age 12 for males. The 900-924 mm category had the largest proportion of female sheefish, while the 825-849 mm category had the largest proportion of males. An estimated 43,036 (25,241 - 60,831 90% CI) sheefish were in the area between Kobuk Village and Reed River prior to spawning. Tag returns from sheefish marked in 1994 and 1995 suggest non-consecutive spawning. Survey of the subsistence and commercial gillnet fisheries in Hotham Inlet was conducted April 1 - 14, 1996. Twenty-one of 25 participants in the subsistence gillnet fishery on Kobuk Lake were interviewed and the total harvest for the 1995 - 1996 subsistence gillnet fishery was estimated at 15,161 sheefish (95% CI 11,925 - 18,396). Total harvest data for the Kobuk/Selawik sheefish populations is incomplete, but abundance of spawning sheefish is greater than previously thought.

Key words: sheefish, *Stenodus leucichthys,* Kobuk River, abundance estimate, length composition, age composition, spawning, subsistence gillnet harvest.

INTRODUCTION

Sheefish, *Stenodus leucichthys* or inconnu of the Kobuk/Selawik river drainage's are considered estuarine anadromous (Alt 1987). The population is considered a single stock, with a common overwintering area in Hotham Inlet and Selawik Lake and spawning grounds in the upper Kobuk and Selawik rivers (Figure 1). No sheefish are known to spawn in the Noatak River. This study focused on the Kobuk River spawning population; a concurrent study was conducted by the US Fish and Wildlife Service (USFWS) on the Selawik River spawning population.

Kobuk River sheefish migrate long distances upstream to reach spawning areas in late fall, approximately 575 to 650 km upstream of Hotham Inlet. The spawning migration of mature sheefish in the Kobuk River is an extension of the seasonal feeding migration of the population which begins soon after ice breakup in the spring. Sheefish move upstream rapidly, reaching Kiana, 100 km upstream from the mouth of the Kobuk River, by late June. Nonspawning adults and immature sheefish seldom migrate more than 180 km upstream from the mouth of the Kobuk River, but spawners continue upriver reaching Ambler in mid-July. As fish reach Ambler, 265 km upstream from the mouth of the Kobuk River, the migration slows and fish disperse. They reach spawning areas between Kobuk Village and Reed River (544 to 672 km upstream from the mouth of the Kobuk River) from August through early September (Figure 2). Spawning occurs a few days prior to the beginning of freeze up (appearance of frazzle ice). A downstream migration occurs after spawning (Alt 1969 and 1987). Alt (1987) found only one nonspawning sheefish in the vicinity of the spawning grounds. It is therefore assumed that all sheefish encountered above Kobuk Village will be spawners.

The Kobuk/Selawik population contains the largest sheefish in Alaska; individuals up to 26.5 kg have been captured (Alt 1987). Because of their large size and relatively easy access, Kobuk River sheefish are highly sought by sport anglers. Since the inception of the Alaska Department of Fish and Game (ADF&G) trophy fish program in 1967 through 1995, 12 of 14 trophy sheefish registered have been taken from the Kobuk River. All official Hall of Fame 1996 world fresh
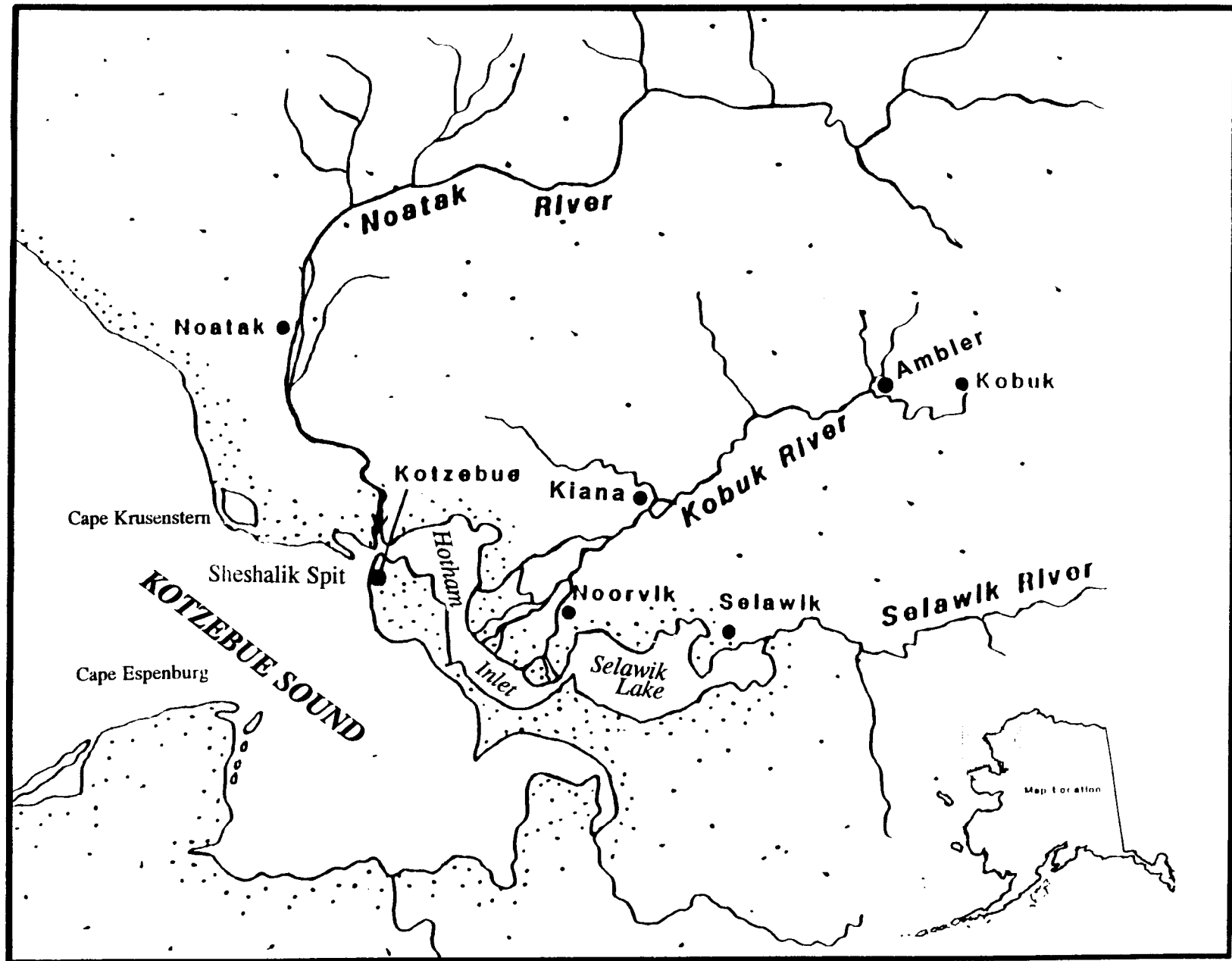
Figure 1.-Map of Kobuk River and surrounding area.

Section I
(48 km)

Section II
(32 km)

Section III
(50 km)

Mauneluk
River

Kobuk
Village

Lake
Selby

Reed
River

Gates
of the

Kobuk
River

Selby
River

Arctic

National

Preserve

Pah
River

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0        10       20       30       40   km
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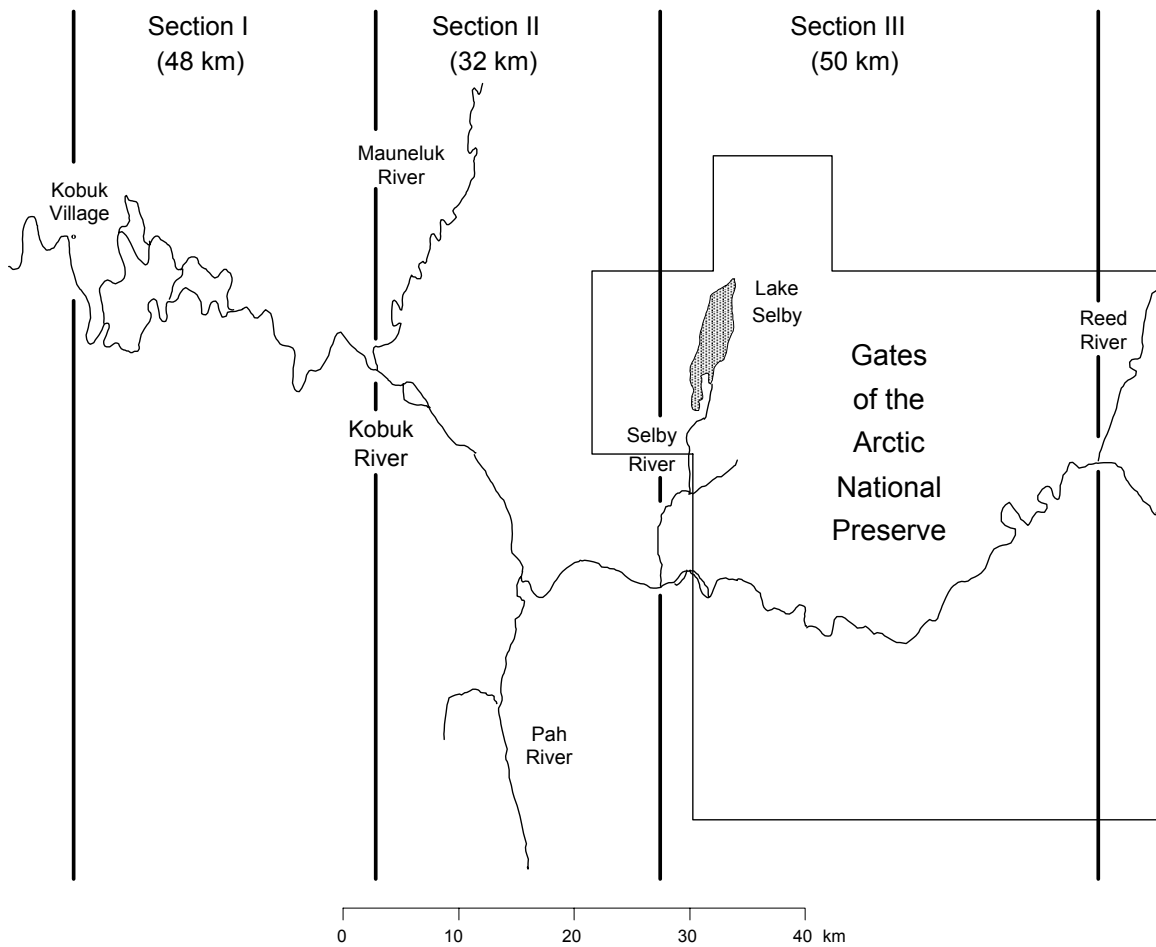
Figure 2.-Area of the Kobuk River sampled for sheefish in 1996.

water fish records of North America (tackle and line class) for sport angled sheefish are from fish caught in the Kobuk River (National Fresh Water Fishing Hall Of Fame, Hayward, Wisconsin).

Estimated sport fish harvests of these fish from the Kobuk River from 1977 to 1995 have averaged 814 fish, ranging from 131 in 1989 to 1,886 in 1982 (Mills 1979 - 1994, Howe et al. 1995, 1996). During this time period sheefish from the Kobuk River have accounted for 34% of the statewide sport harvest of sheefish and 59% of the sport harvest of sheefish for northwestern Alaska. Estimated sport fish catches of these fish from the Kobuk River from 1990 to 1995 have averaged 1,345 fish (Mills 1991 - 1994, Howe et al. 1995, 1996). During this time period the Kobuk River has accounted for 27% of the statewide and 66% of the northwestern Alaska sport catch of sheefish.

Current sport fishing regulations for sheefish in the Kobuk River are: 2 per day, 2 in possession, with no size limit for sheefish upstream of the mouth of the Mauneluk River (see Figure 2) and 10 per day, 10 in possession, with no size limit for the remainder of the Kobuk River. Prior to 1988 the sport fishing regulations for sheefish in the Kobuk River were 10 fish per day, no possession limit, and no size limit. Concerns for the maintenance of this sheefish stock and

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continuance of this unique trophy fishery were the motivation behind these proposals submitted by ADF&G to and adopted by the Alaska Board of Fisheries in 1987.

In addition to supporting an important sport fishery in the Kobuk River, Kobuk/Selawik sheefish are taken in both subsistence and commercial fisheries (Appendix A). The major harvest is for subsistence with reported harvests as high as 31,292 sheefish (Lean et al. 1996). The subsistence harvest reports are incomplete and should be considered minimum harvest numbers. Prior to 1994, subsistence harvest was not the estimated harvest of all fishery participants, but only the harvest of the participants interviewed. In addition, in many years the reported subsistence harvest was from the Kobuk River villages and not the Kotzebue District as a whole, which includes winter gillnet and spring hooking fisheries on Kobuk and Selawik lakes. From 1967 through 1995 the estimated commercial harvest has averaged 1,203 fish. Lean et al. (1996) suggest that commercial harvests have remained relatively high. It is suspected that the undocumented commercial harvest is significant and totals should be considered minimum estimates. The subsistence fishery occurs throughout the Kotzebue District which includes the Kobuk and Selawik rivers, Selawik Lake, and Hotham Inlet (Lean et al. 1996).

Currently the subsistence fishery is not regulated. Lean et al. (1996) reported that during the 1960's, age, sex, and length data indicated sheefish stocks were being overharvested by commercial and subsistence fisheries in the Kotzebue district. Consequently, an annual area commercial harvest quota of 25,000 pounds of sheefish was instituted.

Data on the number of sheefish spawning in the Kobuk River are intermittent and the result of aerial surveys conducted by ADF&G Division of Commercial Fisheries Management and Development (CFMD). Between 1966 and 1971, aerial counts averaged 3,706 and ranged from 1,025 to 8,166 (Alt 1987). Intermittent aerial counts since 1979 (1979, 1980, 1984, 1991, and 1992) have averaged 5,617 and have ranged from 1,772 to 17,335 (Lean et al. 1996). A mark-recapture experiment conducted in 1970 estimated 7,130 spawners, while an aerial survey in 1970 counted only 3,220 spawners (Alt 1987). In 1995, mark-recapture experiments were conducted on the Kobuk and Selawik rivers by Sport Fish Division (ADF&G) and USFWS. From these studies, estimates of spawning sheefish on the Kobuk and Selawik rivers were 32,273 and 5,190, respectively (Taube 1996, Tevis Underwood, USFWS, Fairbanks, personal communication).

Past work on sheefish in Alaska was summarized by Alt (1987) and includes data on the ecology, movements, growth, and stock status of all known Alaskan stocks. The Subsistence Division (ADF&G) investigated conflicts (real and perceived) between user groups on the upper Kobuk River in 1989 (Georgette and Loon 1990). Prior to 1994, the Sport Fish Division has had no projects directed toward Kobuk River sheefish since 1979.

The goal of this project is to describe the stock status of spawning sheefish in the upper Kobuk River. In order to accurately and precisely describe the stock status of spawning sheefish in the upper Kobuk River, project objectives and tasks for the 1996 Federal Aid project F-10-12, R-3-5(b) were to estimate:

1. the abundance of sheefish spawning in a 130 km reach of the upper Kobuk River such that the estimate is within 25% of the true abundance 90% of the time;

2. the length and age compositions of sheefish spawning in a 130 km reach of the upper Kobuk River such that the estimates are within 5 percentage points of the actual values 95% of the time;

3. the length and age compositions of sheefish examined from the spring subsistence fishery at Hotham Inlet such that the estimates are within 10 percentage point of the actual values 95% of the time; and,

4. the harvest of the 1995-96 subsistence and commercial gillnet fishery at Hotham Inlet.

Project tasks were to:

1. test the hypothesis that the proportion of recaptures to marks of sheefish marked in 1994 is equal to or less than the proportion of recaptures to marks of sheefish marked in 1995 to determine if consecutive or non-consecutive spawning exists;

2. examine the subsistence fishery for the proportion of marked fish captured by hook and line during the first event to determine if mortality due to gear occurs between events; and,

3. continue the collection of paired sampled of otoliths and scales for age validation.

METHODS

DATA COLLECTION

The study area for the abundance estimate consisted of a 130 km stretch of the Kobuk River divided into three sections: 1) Kobuk Village to the Mauneluk River (48 km or 30 miles); 2) Mauneluk River to the Selby River (32 km or 20 miles); and 3) Selby River to the Reed River (50 km or 31 miles) (Figure 2). Work conducted by Alt (1969) showed no evidence of spawning sheefish in the tributaries, so data collection was confined to the mainstem Kobuk River. Sampling occurred from July 30 - September 22, 1996, throughout the study area.

The marking event occurred from July 30 - September 3 and the recapture event occurred from September 4-22. Sheefish were sampled using hook and line and 61.5 m beach seine during both events. In addition, the subsistence gillnet fishery was sampled during the recapture event. The start of the recapture event in 1996 occurred when catch rates of sheefish in section one were essentially non-existent and it was assumed that all spawners were within the study area.

A crew of four to six persons sampled sheefish with hook and line from two boats (two to three crew members per boat). These fish were located and caught primarily in the main channel of the Kobuk River in moderate velocity water off the river bottom. Length, sex, tag number, finclip, date, and river mile were recorded on Tagging Length Version 1.0 mark-sense forms. All captured sheefish were examined for Floy tags and prior finclips and measured to the nearest millimeter of fork length. During both events, untagged sheefish judged to be in a healthy condition were released after being marked with an individually numbered Floy FD-67 internal anchor tag inserted at the base of the dorsal fin so that the tag locked between the posterior interneural rays. All fish marked with a Floy tag were also marked with a upper caudal fin clip in case tag loss occurred between events. The sex and maturity of each live fish was determined by the presence of sex products. Fish for which sex could not be determined were recorded as neither male or female. Sheefish were landed as expediently as possible and usually processed in

under 30 s. Fish were then held in the water, head facing the current and released once they were judged to be in a healthy condition. Fish that were injured or severely bleeding were not tagged. At least three scales were taken from the left side of the body just posterior of the dorsal fin approximately midway between the lateral line and the base of the dorsal fin (Alt 1969). Scales of sheefish captured by hook and line were immediately mounted onto gum cards or placed in coin envelopes (labeled to correspond to the mark sense forms) prior to being transferred onto gum cards. Scale impressions were made on 20 mil acetate sheets using a Carver press at 241,315 kPa (35,000 psi) heated to 145° C for 135 s. Scales were read on a Micron 770 microfiche reader (32X). Annulus determination was made using criteria described by Alt (1969). Ages were then recorded into the edited data file.

Sheefish sampled by beach seine were processed in the manner described above. One boat and a crew of at least four was used during seining. Sheefish were found and seined in shallow (< 2.0 m), high velocity water, usually on the downstream end of a gravel bar. A rope harness was attached to each end of the seine with a 16 m lead. One or two crew members remained on the upstream portion of the gravel bar holding one lead, while the remaining crew pushed the boat into the current. The seine was set as perpendicular (cross-current) to the shore as possible, while the current took the boat downstream. To accomplish this, the onshore crew members would walk the net down the shoreline, until all the net was out and the boat motored the other lead to shore. The ends of the leads were brought together and the seine was pulled to shore. A portion of the seine was left in the water to hold the captured sheefish, until all were processed. Due to the swift current, several hundred yards of shoreline was required to dispatch and haul in the seine.

Sheefish caught in the subsistence fishery were examined whenever permission was granted by the subsistence users. These fish were examined for tags and secondary marks, length and sex were recorded and scale samples were taken.

In 1996, the spring hooking fishery in Hotham Inlet was sampled during April 1 - 14, and sampling was conducted by a two to four person crew on snowmachines. This fishery occurs during the longer and warmer days of spring, and consists of an angler using a bow-shaped section of antler or wood with heavy test braided or monofilament line wrapped around it and jigging a large spoon. When a angler or group of anglers were sighted, permission to sample their catch was obtained. All sheefish hooked by a angler were sampled for length and age data and examined for tags.

A survey of participants in the Hotham Inlet (Kobuk Lake) winter gillnet fishery was begun during sampling in April and completed in May by ADF&G Sport Fish and CFMD personnel. All individuals who participated in the subsistence and commercial gillnet fishery were contacted by phone or in person. Participants were not interviewed until after their gillnets were pulled for the season. A questionnaire was completed for each individual interviewed. Names of the participants were not recorded on the questionnaire to insure anonymity. A copy of the questionnaire is found in Appendix B.

ABUNDANCE ESTIMATION

The number of sheefish spawning in the Kobuk River was estimated using the Bailey modification of the Petersen estimator (Seber 1982). Population abundance and the approximate variance of the estimate was calculated with the following formulas (Seber 1982).

$$\hat{N} = \frac{M(C+1)}{(R+1)} \qquad (1)$$

$$V[\hat{N}] = \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)} \qquad (2)$$

where:

M = the number marked during the first sampling event;

C = the number examined during the second sampling event; and,

R = the number captured during the second sampling event with marks from the first sampling event.

A two event mark-recapture experiment on a closed fish population is unbiased if the following conditions are met:

1. catching and handling the fish does not affect the probability of recapture;

2. fish do not lose marks between events;

3. recruitment and mortality do not occur between sampling events (recruitment or mortality can occur, but not both);

4. every fish must have an equal probability of being marked and released alive during the first sampling event; or every fish must have an equal probability of being captured during the second sampling event; or marked fish mix completely with unmarked fish between sampling events (Seber 1982).

Condition 1 was assumed to be met because only sheefish that were judged to be in good condition after capture were marked prior to being released. Condition 2 was met by double marking each fish (Floy tag and finclip) in order to determine if marks were lost between events. In regards to condition 3, the targeting of sheefish by the subsistence fishery occurred during the recapture event, any mortality that occurred during the marking event was assumed to be negligible. However, there was a possibility that not all pre-spawning sheefish were on the spawning grounds prior to initiation of the marking event and as such condition 3 would be violated. Marked-to-unmarked ratios by each river section during each week of the recapture event were evaluated to determine if recruitment to the population had occurred.

To evaluate condition 4, the marked-to-unmarked ratio at each river section during the recapture event was compared using the Chi-square statistic and contingency table. Movement and/or mixing of marked sheefish with unmarked sheefish was determined by visual comparison of the frequency of marked fish recaptured in the recapture event that moved from one river section to another with the frequency of unmarked fish examined in the recapture event in each river section (Appendix C1).

The hypothesis of equal probability of capture of fish by size between each sampling event was tested with Kolmogorov-Smirnov two sample tests (Appendix C2). The first test involved the lengths of marked fish recaptured during the recapture event versus the lengths of those fish

marked during the marking event. The second test compared the lengths of fish marked during the marking event with fish examined during the recapture event (Seber 1982).

To determine if consecutive spawning exists the chi-square statistic and contingency table were used. The null hypothesis that the proportion of sheefish marked in 1994 and recaptured in 1996 to sheefish marked in 1994 is equal to the proportion of sheefish marked in 1995 and recaptured in 1996 to sheefish marked in 1995. A 2 by 2 contingency table for year of mark by 1996 recapture status was used. The total of the columns was the number of sheefish marked in that year at large prior to sampling in 1996. If the null hypothesis is rejected, another factor or combination of factors such as mortality or non-consecutive spawning had an effect on the number of marked fish in the study area during sampling in 1996.

AGE AND LENGTH COMPOSITION

The abundance estimate was stratified due to size-selectivity in the sampling gear and estimates of length and age composition were calculated as follows:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \tag{3}$$

where:

$n_i =$ the number sampled from stratum i in the mark-recapture experiment;

$n_{ij} =$ the number sampled from stratum i that belong to group j; and,

$\hat{p}_{ij} =$ the estimated fraction of the fish in group j in stratum i.

Note that $\sum\limits_{j=1}^{L} p_{ij} = 1$ (where L is the number of size groups). The variance for $\hat{p}_{ij}$ is:

$$\hat{V}\left[\hat{p}_{ij}\right] = \frac{\hat{p}_{ij}\left(1 - \hat{p}_{ij}\right)}{n_i - 1} \tag{4}$$

The estimated abundance of sheefish in group j in the population is:

$$\hat{N}_j = \sum\limits_{i=1}^{S} \hat{p}_{ij}\hat{N}_i \tag{5}$$

where:

$\hat{N}_i =$ the estimated abundance in stratum i of the mark-recapture experiment; and

$S =$ the number of strata in the mark-recapture experiment.

The variance for $\hat{N}_j$ is approximated by the delta method (Seber 1982):

$$\hat{V}\left[\hat{N}_j\right] = \sum\limits_{i=1}^{S}\left(\hat{V}\left[\hat{p}_{ij}\right]\hat{N}_i^2 + V\left[\hat{N}_i\right]\hat{p}_{ij}^2\right). \tag{6}$$

The estimated fraction of the population that belongs to group j is:

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}}$$

(7)

where: $N = \sum\limits_{i=1}^{s} N_i$.

The variance of the estimated fraction can be approximated with the delta method (see Seber 1982):

$$\hat{V}\left[\hat{p}_j\right] = \sum_{i=1}^{S}\left\{\hat{V}\left[\hat{p}_{ij}\right]\left[\frac{\hat{N}_i}{\hat{N}}\right]^2\right\} + \frac{\sum\limits_{i=1}^{S}\left\{V\left[\hat{N}_i\right]\left(\hat{p}_{ij} - \hat{p}_j\right)^2\right\}}{\hat{N}^2}$$

(8)

SUBSISTENCE GILLNET HARVEST

The estimated harvest of the subsistence and commercial gillnet fishery and the approximate variance of the estimate was calculated with the following formulas (Cochran 1977).

$$\hat{y} = N\overline{y}$$

(9)

$$V(\hat{y}) = \frac{N^2 s^2}{n}\left(1 - \frac{n}{N}\right)$$

(10)

where:

        N = the total number of gillnet fishery participants

        n = the number of participants reporting harvest

        $\overline{y}$ = the estimate of the mean reported harvest

        s = the variance of the reported harvest

RESULTS

Abundance Estimation

A total of 1,392 sheefish were marked during event 1, and 1,120 sheefish were examined during event 2 (Table 1). Seventy-seven of the 1,392 sheefish were marked between July 30 - August 12 from 6 km to 50 km above Kobuk Village by Ken Alt, a retired ADF&G biologist working in the area. Thirty-six marked sheefish were recaptured during the second event, 25 by seine, eight by gillnet and three by hook and line. All gear types had similar proportions of marked to unmarked

Table 1.-Sheefish marked, examined, recaptured, and Recaptured/Examined ratio by event, gear type, and river section, 1996.

Gear Type	River Section	Event 1 7/30 - 8/12/96 8/17 - 9/03/96 Sheefish Marked (M)	Event 2 9/4 - 9/22/96 Sheefish Examined (C)	Sheefish Recaptured (R)	R/C
	1	0	0	0	0
Seine	2	94	87	2	0.023
	3	0	713	23	0.032
	Total	94	800	25	0.032
	1	360	0	0	0
H & L	2	792	49	0	0
	3	146	96	3	0.031
	Total	1,298	145	3	0.021
	1	0	0	0	0
Gillnet	2	0	135	5	0.037
	3	0	40	3	0.075
	Total	0	175	8	0.048
Total		1,392	1,120	35	0.033

sheefish during event 2. No sheefish were captured in section 1 during the second event. Since sampling effort was distributed throughout the study area, it was assumed that the majority of sheefish had moved out of section 1 and into sections 2 and 3. To prevent bias due to a sample size of zero, section 1 was not included when condition 3 and 4 were tested.

Only 7% of sheefish marked during event 1 were captured by seine, the remaining 93% were captured by hook and line. The majority of seining sites are located in section 3 and sheefish were not at these sites in sufficient numbers to seine during event 1. No sheefish were netted in the subsistence fishery during event 1, because the subsistence fishery targets salmon and whitefish during this time. During the second event, 16% of the sheefish examined were captured by subsistence gillnet, 13% by hook and line, and 71% by seine. Of sheefish marked by hook and line and by seine, the proportions recaptured during the second event were not significantly different ($\chi^2 = 1.118$, P = 0.29). This indicates that mortality between sampling gear is not different and the abundance estimate is not biased due to gear selective mortality.

The condition that recruitment does not occur between sampling events was not violated. There was no significant difference in the marked to unmarked ratio by section during each week of event 2 (section 2: $\chi^2 = 2.827$, P = 0.24; section 3: $\chi^2 = 1.047$, P = 0.31), therefore recruitment to the population was unlikely. Since the subsistence gillnet fishery did not target sheefish during the first event, it was assumed that mortality during event 1 was negligible. Therefore, since both mortality and recruitment did not simultaneously occur during either event, the abundance estimate is germane to the time of the marking event (July 30 - September 3, 1996).

Ten marked sheefish were recovered by a subsistence gillnet in Ambler (approximately 60 miles downstream of Kobuk) during September 4 - 8. Unmarked fish were also caught with these marked sheefish and it was assumed that marking was not a cause for the downstream migration. Based on these fish, emmigration out of the spawning area did occur during the recapture event. Since the estimate is germane to the marking event, there is no bias due to emmigration during the recapture event. Catches of sheefish in section 1 dropped significantly by the end of the marking event, consequently all spawning sheefish were considered to be on the spawning grounds prior to the start of the recapture event.

There was no significant difference in the marked-to-unmarked ratio at each section ($\chi^2 = 0.431$, P = 0.51), therefore the capture probability of marked fish was the same in all river sections (Table 1). This indicates that movement and/or complete mixing of marked and unmarked fish occurred across river sections and catchability of marked and unmarked fish was equal. Therefore, condition 4 was not violated and stratification by river section for the abundance estimate was not necessary. Of the 36 sheefish marked during the first event and recaptured during the second, 75% moved upstream to another section, 14% stayed within the section in which it was marked, and 11% moved downstream. The greatest distance traveled by marked sheefish (4) until recapture was 88 km (55 miles), the least distance traveled by a marked sheefish (1) was 0 km. Five sheefish traveled 5 km or less from the time of marking to the time of recapture. The average number of days between marking and recapture for these five sheefish was 17. On the average, marked sheefish traveled 38 km (24 miles) from the point of marking to point of recapture. The greatest number of days between marking and recapture was 52, the least was 3. On the average, marked sheefish were recaptured 20 days after initial marking.

There was a significant difference between the lengths of sheefish marked during the first event and marked sheefish recaptured during the second (D = 0.2886, P = 0.007). There was a significant difference in lengths of fish marked during the first event and fish examined during the second (D = 0.1995, P = 0). According to the criteria followed to detect bias due to unequal catchability by length, stratification by length was necessary for the abundance estimate (Appendix C2). The Chi-square test based on the proportions of recaptured sheefish to marked sheefish by size stratum determined a significant difference at 831 mm and estimates for sheefish ≤ 831 mm and sheefish > 831 mm were calculated. The estimate of abundance and variance for each strata were combined for the total estimate. There was size-selectivity during the second sampling event and it is unknown whether size-selectivity occurred during the first. The lengths and ages from the second event were used to estimate length and age composition and were adjusted for size bias. The abundance of spawning sheefish on the Kobuk River between Kobuk Village and Reed River in 1996 was 43,036 (25,241 - 60,831 90% CI).

Age and Length Composition
Kobuk River
Length and age composition samples were taken from all unique sheefish examined during the second event. The largest proportion of sheefish in the population was in the 825-849 mm category (p = 0.17, SE = 0.032) (Figure 3). The largest proportion of female sheefish in the sample was in the 900-924 mm category (p = 0.21, SE = 0.017) and in the 825-849 mm category for the male sheefish (p = 0.17, SE = 0.017). Length distribution of female sheefish examined was significantly different than that of male sheefish (D = 0.669, P = 0) (Figure 3). The mean length of all sheefish examined was 876 mm (n = 1,088). Mean length of male sheefish was 817 mm (n = 490) and 928 mm (n = 558) for females. Sex was not determined for 40 sheefish examined during the second event.

The ages of all sheefish examined ranged from 8-22 years, male sheefish ranged in age from 8 to 20 years, while female sheefish ranged from 9 to 22 years. The largest proportion of male sheefish was age 12 (p = 0.21, SE = 0.019) and female sheefish was age 14 (p = 0.21, SE = 0.018). Age 11 (p = 0.17, SE = 0.031) and age 12 (p = 0.17, SE = 0.029) fish were the largest proportion of all 997 sheefish examined.

Sex composition of sheefish examined in 1996 was 53% female and 47% male, compared to 54% male and 46% female in 1995. Alt (1969) also reported a composition of 54% male and 46% female sheefish in the area of the Kobuk River spawning grounds.

Fifteen of 609 sheefish marked in 1994 and still assumed at large were captured during sampling in 1996. Eight of 1,327 sheefish marked in 1995 and still assumed at large were captured during sampling in 1996 (Table 2). There was a significant difference in the proportion of sheefish marked in 1994 and 1995 and recaptured in 1996 (χ^2 = 12.43, P = 0.0004). This difference suggests that non-consecutive spawning occurs in some Kobuk River sheefish. Since no sheefish are known to spawn in the Noatak river, and tag returns have not shown any evidence of Kobuk River spawners in the Selawik River, it is not highly likely that Kobuk River fish spawn elsewhere. The proportion of the spawning population that does not return the following year cannot be determined from the data available. Of the eight sheefish marked in 1995 and recaptured in 1996 only one was female. Five of the fifteen marked in 1994 and recaptured in 1996 were female.
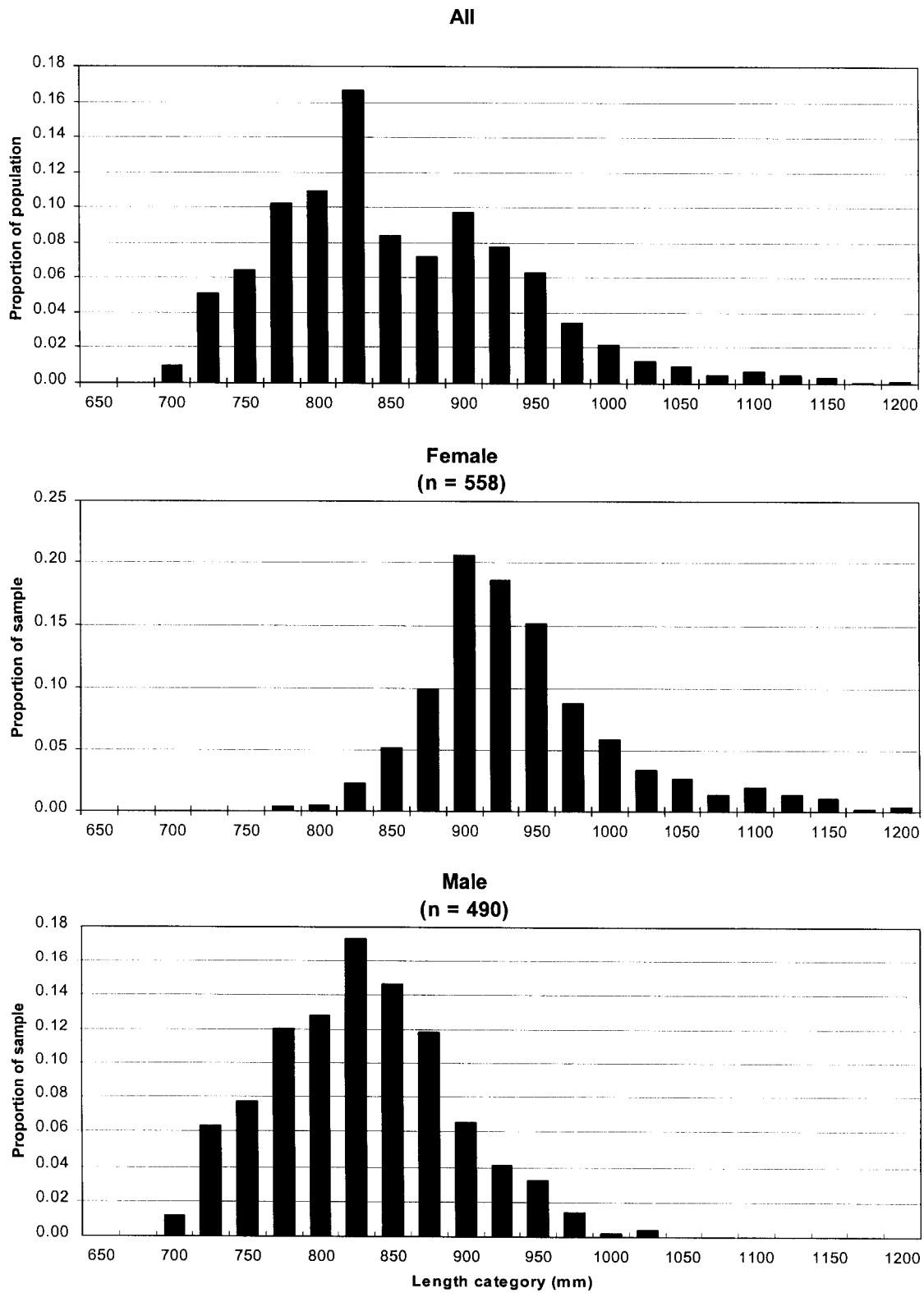
Figure 3.-Length composition of sheefish examined from the Kobuk River during sampling in 1996.

Table 2.-Number of sheefish marked in previous years sampling that were recaptured in 1996.

Recaptured in 1996	Year Sheefish Were Marked	
	1994	1995
yes	15	8
no	594	1,327
Total	609	1,335

Thirty-nine percent of all sheefish marked during the first event were captured around 64 km (river mile 40) above Kobuk Village, this area was the main holding area for sheefish during August and early September and also the site of the project base camp. Forty-nine percent of all sheefish examined during the second event were captured around 94 km (river mile 59) above Kobuk Village, this was a primary spawning/holding area for sheefish in September. Only 175 sheefish captured by subsistence gillnets were examined during the recapture event. This was due to low water levels, which prevented many of the subsistence users from accessing the locations where high numbers of sheefish were congregated. In 1995, the majority of sheefish examined from the subsistence fishery were captured at 64 km above Kobuk Village. In 1996, the subsistence nets began to target sheefish in mid-September and the majority of sheefish had moved above the 1995 site. Other sites at which sheefish were captured (during either event) are found in Appendix D.

Hotham Inlet

Length and age composition samples were taken from all unique sheefish examined from the subsistence hooking fishery on Hotham Inlet during April 1996. Sex was not determined since sheefish were not examined internally. The largest proportion of sheefish were found in the 600 mm category (Figure 4). Average length of all fish sampled was 658 mm. The ages of all sheefish examined on Hotham Inlet ranged from 4 to 17 years, with age 7 and age 8 the predominant age classes (p = 0.250/0.252, SE = 0.020/0.020). Alt (1987) sampled 138 sheefish taken by the hooking fishery in the winter of 1987 and reported an age range of age 4 to 18 and an average length of 684 mm. Ten percent of sheefish sampled were < 525 mm and 58% were < 650 mm. In comparison, sheefish harvested in the gillnet fishery < 0.05% were < 525 mm and 10% were < 650 mm. A summary of length and age composition data of sheefish examined on the Kobuk River and Hotham Inlet in 1996 is found in Appendix E.

Twenty-one of 25 participants in the subsistence gillnet fishery on Kobuk Lake were interviewed during April and May 1996. Twenty-nine nets were fished by the 21 participants and the average number of days nets were fished was 83. The gillnet fishery usually occurs from early November through late April. An average of 606 sheefish were harvested by each survey participant. The estimated total harvest for the 1995 - 1996 subsistence gillnet fishery was 15,161 sheefish (95% CI 11,925 - 18,396).
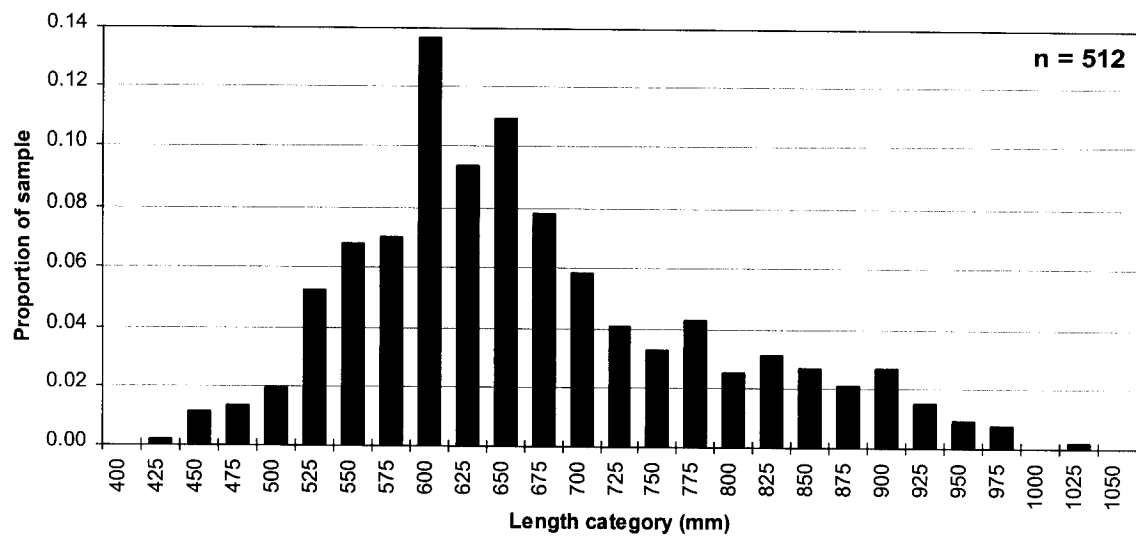
14

Figure 4.-Length composition of sheefish examined from Hotham Inlet hooking fishery during sampling in 1996.

DISCUSSION

Tag loss did not appear to be a problem during sampling in 1996. Only one sheefish captured had secondary marks without having a Floy tag. Mortality due to sampling appeared to be low, no immediate mortalities occurred in sheefish captured by seine. Less than 0.5% of sheefish captured by hook and line died immediately due to sampling method (5 of 1,443). Several fish were released that had been bleeding from the gills, but they were not tagged. These fish were held in the water alongside the boat until they swam away strongly. There were no reports from other users of the river that tagged sheefish were observed behaving erratically or found dead. It is therefore believed that immediate mortality due to handling and sampling methods was negligible.

During sampling in 1996 two sheefish < 600 mm were captured (536 and 560 mm) above Kobuk Village. In 1995, the smallest sheefish examined was 667 mm. Both of the sheefish in 1996 were age 7 males. Male sheefish become sexually mature at age 7 (Alt 1987), and it is likely that these sheefish were sexually mature, but no sex products were extruded and the fish were not internally examined. Alt (1987) only found one nonspawning sheefish in the vicinity of the spawning grounds during his study. Based on this information it was assumed that all sheefish above Kobuk Village were spawners. To verify this assumption in 1997, sheefish under 600 mm should be examined to determine whether they are in spawning condition.

In some Russian populations, sheefish are believed to spawn every 3 to 4 years (Nikol'skii 1954). Based on examination of sheefish ovaries, Alt (1987) suggests that non-consecutive spawning occurs in the Kobuk-Selawik River populations. Alt also states that based on tag recoveries on the upper Kobuk River spawning grounds, some sheefish are capable of consecutive spawning, especially small males. Data collected from 1995 and 1996 supports this information. Four sheefish that had been marked during sampling in 1994 were recaptured during sampling on the Kobuk River in 1995. All four of these fish were males. In 1996, eight sheefish marked in 1995 were recaptured, only one of these was a female. Fifteen sheefish marked in 1994 were recaptured in 1996, ten of these were male and five were female. Based on these tag recoveries, males are more likely to return to spawn the following year than females. Without following individual sheefish, it would be difficult to determine the actual interval between spawning. Tag recoveries in 1997 should provide additional information on spawning intervals in Kobuk River sheefish.

Hook and line was not effective in capturing marked sheefish during the second event in 1995 (Taube 1996). This was attributed to gear avoidance, however, in 1996 three sheefish were recaptured by hook and line. There was no significant difference during the recapture event in 1996 between gear type for marked to unmarked sheefish, indicating no gear avoidance. Why no sheefish were recaptured by hook and line in 1995 is unclear. In fact, over twice as many sheefish were captured by hook and line during the second event in 1995 (349) than in 1996 (145). Based upon the results of 1996, one would expect at least some sheefish recaptured by hook and line in 1995. One explanation may be timing of the sampling events - in 1996, all three recaptured sheefish were caught between September 9 - 12. In 1995, only 58 sheefish were caught from September 8 - 12, and 291 sheefish were caught from September 12 - 24. Only four sheefish in 1996 were caught after September 12 (September 14 - 15). Based on observations from 1995 and 1996, sheefish are more difficult to catch by hook and line as the spawning period

approaches. Greater effort was directed toward hook and line sampling in 1995, hence the larger sample. This lower catchability of sheefish as spawning approaches may explain why no marked sheefish were recaptured in 1995. If hook and line sampling is to be effective for both events of mark-recapture experiments, it would be best to conduct the sampling well before the spawning period.

The ratio of male to female sheefish on the spawning grounds in 1996 was different than 1995. Forty sheefish in 1996 were not identified as male or female as opposed to six in 1995. This difference would still not account for the higher proportion of females in 1996. Kirilov (1962) reported 65% males and 35% females in the Vilyui River, but mentioned that the sex ratio changed from year to year. Non-consecutive spawning may be responsible for the variation between years. If this is the case, ratio of males to females on the spawning grounds, may not be indicative of the male:female ratio for all spawners.

Alt (1969) estimated the total sheefish harvest for Kobuk/Selawik area in 1965 was 34,000 - 37,000. Of this 85% were harvested by subsistence users, 10% by the commercial fishery, and 5% by the sport fishery. The Selawik area accounted for 19,000 - 22,000 and the Kobuk/Kotzebue area provided the remaining 15,000 of the harvest. An estimated 31,200 sheefish were harvested in 1967 (Alt 1987). In comparison, nearly 26,000 sheefish were estimated to have been harvested by the Kobuk Lake winter gillnet fishery, Kobuk River villages, and the Northwest Alaska sport fishery. This estimate does not include the Selawik area harvest (Selawik Lake winter gillnet fishery, Selawik Lake subsistence hooking fishery, and the Selawik River spring subsistence harvest gillnet and hook and line) and the Hotham Inlet winter hooking fishery. Alt (1987) reported that the largest portion of the subsistence harvest came from the hook and line fishery through the ice at Selawik Lake and Hotham Inlet, an estimated 11,000 - 12,000 in 1965. Since that time, no estimate of this harvest has occurred. The estimated subsistence harvest from the Kobuk River villages does incorporate harvest for the entire year, including the Noorvik residents hooking harvest. A survey of this fishery would prove logistically difficult. Fishing occurs throughout Hotham Inlet and Selawik Lake, though traditional fishing areas are present. While primary participants of this fishery reside in Kotzebue, Selawik, Noorvik, Kiana, and Ambler, occasionally residents of other Kotzebue and Norton Sound communities also participate. If the Selawik area fisheries harvest is at a minimum half of what they were in 1965, the harvest of Kobuk/Selawik River sheefish for 1995 would be at least 36,000. This is similar to the 1960's estimate, but without information on the Selawik fisheries and the hooking fishery this can only be considered speculation.

In spring 1997, ADF&G and USFWS are planning to conduct surveys of the gillnet fisheries on Hotham Inlet and Selawik Lake. The information from Selawik Lake will give an indication of whether harvests in the Selawik area have decreased from levels during the 1960's. Until the hooking fishery harvest is estimated, the total harvest of sheefish is incomplete. It would appear that harvest levels are similar to levels during the 1960's, though the larger proportion of the harvest may have shifted to the Hotham Inlet/Kotzebue area. The new information provided by the abundance estimates has revealed a larger spawning population than previously thought.

Based on sampling of the Hotham Inlet gillnet and hooking fisheries, not all sheefish harvested are spawners, unlike the fall Kobuk River gillnet harvest where essentially all of the sheefish harvested are spawners. Since consecutive spawning may not occur, the actual abundance of spawners could be higher than estimates from 1995 and 1996. No estimate of the proportion of

spawners returning and the proportion of first time spawners recruiting in a given year has been determined. To estimate abundance of all spawners this information is necessary. In addition, no estimate of immature sheefish has been conducted. Immature sheefish of age 2 and older have been captured in Hotham Inlet, but never in large numbers. Preliminary life history studies of immature and juvenile sheefish would need to be conducted before population estimates could be attempted.

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APPENDIX A

Appendix A1.-Sheefish sport fish harvests and catch, 1977-95 (Mills 1977-94, Howe et al. 1995-96).

Year	Kobuk River Harvest	Kobuk River Catch[a]	NW Alaska Harvest[b]	NW Alaska Catch[a]	Alaska Harvest	Alaska Catch[a]
1977	625	-	656	-	1,247	-
1978	307	-	506	-	1,291	-
1979	682	-	709	-	1,542	-
1980	1,248	-	1,713	-	2,411	-
1981	1,015	-	1,263	-	2,239	-
1982	1,886	-	2,222	-	3,281	-
1983	1,448	-	2,079	-	3,323	-
1984	740	-	3,050	-	3,947	-
1985	1,330	-	1,645	-	2,520	-
1986	1,590	-	3,363	-	3,721	-
1987	865	-	1,836	-	2,597	-
1988	964	-	964	-	3,221	-
1989	131	-	629	-	2,306	-
1990	151	336	151	403	750	3,360
1991	579	1,568	603	1,616	2,256	3,989
1992	627	2,034	1,904	3,678	2,933	6,587
1993	395	1,074	1,029	2,273	1,619	6,666
1994	135	386	564	958	1,511	2,981
1995	748	2,669	1,142	3,270	2,200	6,623

[a] Sport fish catch was not estimated until 1990.

[b] Sheefish harvest is for both fresh and salt water.

Appendix A2.-Reported subsistence sheefish harvests, Kotzebue District, 1966-1996 (taken from Lean et al. 1996)[a].

Year	Number of Fishermen Interviewed	Reported Harvest	Average Catch Per Fishermen
1966-67	135	22,400	166
1967-68	146	31,293	214
1968-69	144	11,872	82
1970	168	13,928	83
1971	155	13,583	88
1972	79	3,832	49
1973	65	4,883	75
1974	58	1,062	18
1975	69	1,637	24
1976	57	966	17
1977	95	1,810	19
1978	95	1,810	19
1979	75	3,985	53
1980	74	3,117	42
1981	62	6,651	107
5/82-4/83[b]	130	4,704	36
5/83-4/84[b]	27	764	28
5/84-9/84	30	2,803	93
1985[c]	2	60	30
1986[b,c]	72	721	10
1987[c]	46	276	6
1988[c,d]	-	-	-
1989[c]	-	-	-
1990[c]	-	-	-
1991	40	2,180	55
1992	43	2,821	66
1993[d]	-	-	-
1994[e]	226 (379)	3,181	8
1995[e]	314 (385)	9,465	25
1996[ef]	352 (390)	6,982	18

[a] Due to limited survey effort during many years total catch and effort should be regarded as minimum figures only and are not comparable from year to year.

[b] Summer catches only; winter catches were not documented.

[c] Villages were not surveyed for subsistence sheefish harvests from 1985 to present; figures shown are catches reported during the fall chum salmon subsistence surveys, and may include summer as well as winter catches.

[d] Subsistence sheefish catches not documented.

[e] Reported harvest is estimated and based on the total number of households in all communities (in parentheses).

[f] Table is updated from preliminary 1996 subsistence survey results.

Appendix A3.-Kotzebue District winter commercial sheefish harvest statistics, 1967-95 (taken from Lean et al. 1996)[a].

Year[b]	No. of Fishermen	No. of Fish	Total Pounds	Average Pounds	Price/Pound	Estimated Value
1967[c]		4,000	26,000	6.5	$0.20	$5,200[c]
1968	10	792	4,752	6.0	$0.22	$1,045
1969	17	2,340	15,209	6.5	$0.25	$3,802
1970[c]		2,206			$0.14	
1971	4	73	720	9.9	$0.13	$95
1972	5	456	4,071	8.9	$0.16	$651
1973	11	2,322	15,604	6.7	$0.20	$3,121
1974	6	1,080[d]	6,265	5.8	$0.30	$1,880
1975	c	2,543[d]	24,161	9.5	$0.30	$7,248
1976	14	2,633	19,484	7.4	$0.30	$5,845
1977	2	566	5,004	8.8	$0.30	$1,501
1978	11	2,870	26,200	9.1	$0.40	$10,480
1979[e]						
1980	4	1,175	8,225	7.0	$0.50	$4,113
1981	1	278	1,836	6.6	$0.75	$1,377
1982	11	2,629[f]	17,376	6.6	$0.75	$13,032
1983	8	1,424	13,395	9.4	$0.50	$6,698
1984	5	927[d]	10,403	11.2	$0.55	$5,722
1985	4	342[d]	3,902	11.4	$0.51	$1,990
1986	2	26	312	12.0	$0.75	$234
1987	3	670	5,414	8.1	$0.49	$2,653
1988	3	943	7,373	7.8	$0.45	$3,318
1989	8	2,335	16,749	7.2	$0.51	$8,542
1990[c]	6	687	5,617	8.2		
1991	5	852	8,224	9.7	$0.50	$4,112
1992	3	289	2,850	9.9	$0.65	$1,853
1993	1	210[d]	1,700	8.1	$0.50	$850
1994[e]						
1995	1	226	2,240	9.9	$0.50	$1,120

[a] Data is not exact, in some instances total catch poundage was determined from average weight and catch data. Similarly, various price/pound figures were determined from price/fish and average weight data.

[b] Season was from October 1 to September 30. Year indicated would be the year the commercial season ended. For example, the year 1980 would represent October 1, 1979 to September 30, 1980.

[c] Data unavailable or incomplete.

[d] Numbers of fish not always reported. Estimates were based on average weights from reported sales which documented the number of fish.

[e] No reported commercial catches.

[f] Estimate based on historical average weight.

APPENDIX B

Appendix B1.-Interview form used for Kobuk Lake gillnet fishery harvest survey.

Hotham Inlet Sheefish Harvest Assessment
1995 - 1996 Kobuk Lake Gillnet Fishery interview form

Community ___Kotzebue___   Interviewer_____ Date _____

I would like to ask you a few questions about the sheefish you caught by gillnet this winter in Kobuk Lake.

How many gillnets did you fish?_____

What day did you set your nets?_____

What day did you pull your nets?_____

How many sheefish did you harvest through the ice by gillnet during the winter of 1995-96?   _____

Did you anyone else fish your net? _____

Does your total harvest include their harvest? _____ If no, who else fished your net?_____

_____

_____

_____

Did you catch any sheefish with tags? _____ If so, did you report the tag to the Kotzebue -ADF&G office?

_____ If not, do you still have the tag and what is the number?_____

_____

_____

_____

Do you have any comments or concerns about sheefish fishing in Kobuk Lake (Hotham Inlet)?

_____

_____

_____

_____

_____

_____

_____

_____

APPENDIX C

Appendix C1.-Methodology to alleviate bias due to unequal catchability by river section.

Result of χ^2 Test[a]	Inspection of Fish Movement[b]

Case I:

           "Accept H_o"   No movement between sections

There is no differential capture probability by river section or marked fish completely mixed with unmarked fish within each river section.

Case II:

           "Accept H_o"   Movement between sections

There is no differential capture probability by river section or marked fish completely mixed with unmarked fish across river sections.

Case III:

           "Reject H_o"   No movement between sections

There is differential capture probability by river section or marked fish did not mix completely with unmarked fish within at least one river section.

Case IV:

           "Reject H_o"   Movement between sections

There is differential capture probability by river section or marked fish did not mix completely with unmarked fish across river sections.

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[a] The χ^2 test compares the frequency of marked fish recaptured during the second event in each river section with the frequency of unmarked fish examined in the second event in each river section. H_o: the capture probability of marked fish in the second event is the same in all river sections.

[b] Inspection of fish movement is a visual comparison of the frequency of marked fish recaptured in the second event that moved from one river section to another with the frequency of unmarked fish examined in the second event in each river sections.

Case I: Calculate one unstratified abundance estimate using the Petersen estimator (Seber 1982).

Case II: Calculate one unstratified abundance estimate using the Petersen estimator (Seber 1982).

Case III: Completely stratify the experiment by river section , calculate abundance estimate for each using the Petersen estimator (Seber 1982), and sum abundance estimates.

Case IV: Completely stratify the experiment by river section . Calculate abundance estimates for each using the Petersen estimator (Seber 1982) and sum estimates. Calculate abundance with the partially stratified model of Darroch (1961) and compare with the sum of Petersen estimates. If estimates are dissimilar, discard the sum of Petersen estimates and use the Darroch estimate as the estimate of abundance. If estimates are similar, discard the estimate with the largest variance.

Appendix C2.-Methodologies for alleviating bias due to gear selectivity by means of statistical inference (Bernard and Hansen 1992).

Results of Hypothesis Tests (K-S and χ^2) on Lengths of Fish Marked during First Event and Recaptured during Second Event	Results of Hypothesis Tests (K-S) on Lengths of fish Captured during First Event and during Second Event
Case I:	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

Case I:	Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.
Case II:	Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.
Case III:	Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.
Case IV:	Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Also, calculate a single estimate of abundance without stratification.
Case Iva:	If the stratified and unstratified abundance estimates for the entire population are dissimilar, discard the unstratified estimate. Only use the lengths, ages, and sexes from the second sampling event to estimate proportions in composition, and apply formulae to correct for size bias to data from the second event.
Case Ivb:	If the stratified and unstratified abundance estimates for the entire population are similar, discard the estimate with the larger variance. Only use the lengths, ages, and sexes from the first sampling event to estimate proportions in compositions, and do not apply formulae to correct for size bias.

APPENDIX D

Appendix D1.-Sampling and subsistence sheefish catch by event, gear type, and river mile[a] during 1996.

River Mile	Event 1 July 30 - August 12, August 17 - September 3		Event 2 September 4-22			Total Catch
	H & L	Seine	H & L	Seine	Gillnet	
4	288	0	0	0	0	288
6	1	0	0	0	0	1
12	1	0	0	0	0	1
15	4	0	0	0	0	4
26	34	0	0	0	0	34
29	32	0	0	0	0	32
30	1	0	0	0	0	1
31	43	0	0	0	0	43
33	10	0	0	0	0	10
38	104	0	2	0	0	106
39	427	0	24	0	0	451
40	200	94	7	87	135	523
42	2	0	0	0	0	2
45	5	0	11	0	0	16
46	0	0	5	0	0	5
50	0	0	2	0	0	2
51	0	0	16	0	0	16
54	0	0	5	0	0	5
55	19	0	0	0	0	19
56	12	0	16	77	0	105
57	17	0	19	21	0	57
58	5	0	1	0	0	6
59	8	0	9	518	0	535
60	79	0	28	14	40	161
63	0	0	0	83	0	83
69	1	0	0	0	0	1
72	5	0	0	0	0	5
Total	1,298	94	145	800	175	2,512

[a] River mile is the distance upstream of Kobuk Village.

APPENDIX E

Appendix E1.-Length composition of sheefish examined during the second event from the Kobuk River, September 4 - 22, 1996.

Length	Female Frequency	pij	V(pij)	SE	Male Frequency	pij	V(pij)	SE	All Fish Nj	V(Nj)	pj	V(pj)	SE
650	0	0	0	0	0	0	0	0	0	0	0	0	0
675	0	0	0	0	0	0	0	0	0	0	0	0	0
700	0	0	0	0	6	0.012	2.47E-05	0.0050	434	49125	0.010	3.08E-05	0.0055
725	0	0	0	0	31	0.063	0.0001	0.0110	2242	635563	0.052	0.0002	0.0142
750	0	0	0	0	38	0.078	0.0001	0.0121	2821	953264	0.066	0.0003	0.0165
775	2	0.004	6.4E-06	0.0025	59	0.120	0.0002	0.0147	4485	2217863	0.104	0.0005	0.0226
800	3	0.005	9.58E-06	0.0031	63	0.129	0.0002	0.0151	4774	2490991	0.111	0.0006	0.0236
825	13	0.023	4.08E-05	0.0064	85	0.173	0.0003	0.0171	7306	5553237	0.170	0.0010	0.0324
850	29	0.052	8.83E-05	0.0094	72	0.147	0.0003	0.0160	3603	487182	0.084	0.0003	0.0176
875	55	0.099	0.0002	0.0126	58	0.118	0.0002	0.0146	3049	364070	0.071	0.0003	0.0185
900	115	0.206	0.0003	0.0171	32	0.065	0.0001	0.0112	4125	629111	0.096	0.0006	0.0240
925	104	0.186	0.0003	0.0165	20	0.041	8.01E-05	0.0089	3279	414867	0.076	0.0004	0.0197
950	85	0.152	0.0002	0.0152	16	0.033	6.46E-05	0.0080	2665	286678	0.062	0.0003	0.0165
975	49	0.088	0.0001	0.0120	7	0.014	2.88E-05	0.0054	1460	103024	0.034	0.0001	0.0102
1000	33	0.059	9.97E-05	0.0100	1	0.002	4.16E-06	0.0020	922	49802	0.021	5.28E-05	0.0073
1025	19	0.034	5.89E-05	0.0077	2	0.004	8.31E-06	0.0029	538	22690	0.013	2.55E-05	0.0051
1050	15	0.027	4.69E-05	0.0068	0	0	0	0	410	15672	0.010	1.81E-05	0.0043
1075	8	0.014	2.53E-05	0.0050	0	0	0	0	205	6544	0.005	7.97E-06	0.0028
1100	11	0.020	3.46E-05	0.0059	0	0	0	0	282	9664	0.007	1.15E-05	0.0034
1125	8	0.014	2.53E-05	0.0050	0	0	0	0	205	6544	0.005	7.97E-06	0.0028
1150	6	0.011	1.91E-05	0.0044	0	0	0	0	154	4666	0.004	5.77E-06	0.0024
1175	1	0.002	3.21E-06	0.0018	0	0	0	0	26	677	0.001	8.78E-07	0.0009
1200	2	0.004	6.4E-06	0.0025	0	0	0	0	51	1394	0.001	1.79E-06	0.0013
	558				490				43036				

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Appendix E2.-Length composition of sheefish examined from Hotham Inlet, April 1996.

Length	Frequency	p	V(p)	SE
400	0	0	0	0
425	1	0.002	3.81E-06	8.63E-05
450	6	0.012	2.27E-05	2.10E-04
475	7	0.014	2.64E-05	2.27E-04
500	10	0.020	3.75E-05	2.71E-04
525	27	0.053	9.78E-05	4.37E-04
550	35	0.068	1.25E-04	4.93E-04
575	36	0.070	1.28E-04	5.00E-04
600	70	0.137	2.31E-04	6.72E-04
625	48	0.094	1.66E-04	5.70E-04
650	56	0.109	1.91E-04	6.10E-04
675	40	0.078	1.41E-04	5.25E-04
700	30	0.059	1.08E-04	4.59E-04
725	21	0.041	7.70E-05	3.88E-04
750	17	0.033	6.28E-05	3.50E-04
775	22	0.043	8.05E-05	3.96E-04
800	13	0.025	4.84E-05	3.08E-04
825	16	0.031	5.92E-05	3.40E-04
850	14	0.027	5.20E-05	3.19E-04
875	11	0.021	4.11E-05	2.83E-04
900	14	0.027	5.20E-05	3.19E-04
925	8	0.016	3.01E-05	2.42E-04
950	5	0.010	1.89E-05	1.92E-04
975	4	0.008	1.52E-05	1.72E-04
1000	0	0	0	0
1025	1	0.002	3.81E-06	8.63E-05
1050	0	0	0	0
Total	512	1		

Appendix E3.-Age composition of sheefish examined during the second event from the Kobuk River, September 4 - 22, 1996.

Age	Female Frequency	pij	V(pij)	SE	Male Frequency	pij	V(pij)	SE	All Frequency	pij	V(pij)	SE
8	0	0	0	0	8	0.018	3.80E-05	0.006	8	0.008	8.42E-06	0.003
9	1	0.002	3.76E-06	0.002	35	0.077	1.56E-04	0.013	36	0.037	3.68E-05	0.006
10	7	0.014	2.60E-05	0.005	57	0.125	2.41E-04	0.016	64	0.066	6.35E-05	0.008
11	33	0.064	1.16E-04	0.011	87	0.191	3.41E-04	0.018	120	0.124	1.12E-04	0.011
12	51	0.099	1.73E-04	0.013	94	0.207	3.61E-04	0.019	145	0.149	1.31E-04	0.011
13	105	0.203	3.15E-04	0.018	81	0.178	3.22E-04	0.018	186	0.192	1.60E-04	0.013
14	108	0.209	3.21E-04	0.018	39	0.086	1.73E-04	0.013	147	0.151	1.32E-04	0.012
15	85	0.165	2.67E-04	0.016	28	0.062	1.27E-04	0.011	113	0.116	1.06E-04	0.010
16	45	0.087	1.55E-04	0.012	15	0.033	7.02E-05	0.008	60	0.062	5.98E-05	0.008
17	35	0.068	1.23E-04	0.011	6	0.013	2.87E-05	0.005	41	0.042	4.17E-05	0.006
18	21	0.041	7.58E-05	0.009	4	0.009	1.92E-05	0.004	25	0.026	2.59E-05	0.005
19	17	0.033	6.19E-05	0.008	0	0	0	0	17	0.018	1.77E-05	0.004
20	5	0.010	1.86E-05	0.004	1	0.002	4.83E-06	0.002	6	0.006	6.33E-06	0.003
21	1	0.002	3.76E-06	0.002	0	0	0	0	1	0.001	1.06E-06	0.001
22	2	0.004	7.50E-06	0.003	0	0	0	0	2	0.002	2.12E-06	0.001
23	0	0	0	0	0	0	0	0	0	0	0	0
Total	516				455				971			

Appendix E4.-Age composition of sheefish examined from Hotham Inlet, April, 1996.

Age	Frequency	p	V(p)	SE
4	6	0.012	2.49E-05	0.005
5	17	0.035	6.90E-05	0.008
6	58	0.119	2.15E-04	0.015
7	122	0.250	3.85E-04	0.020
8	123	0.252	3.87E-04	0.020
9	47	0.096	1.79E-04	0.013
10	39	0.080	1.51E-04	0.012
11	29	0.059	1.15E-04	0.011
12	24	0.049	9.60E-05	0.010
13	17	0.035	6.90E-05	0.008
14	4	0.008	1.67E-05	0.004
15	1	0.002	4.20E-06	0.002
16	0	0	0	0
17	1	0.002	4.20E-06	0.0020
18	0	0	0	0
	488	1		

APPENDIX F

Appendix F1.-Data files used in the preparation of this report.

Data File	Description	Status
X0040L-6.XLS	Sheefish biological data, Kobuk River 1996	Included
X7310L-6.XLS	Sheefish biological data, Hotham Inlet 1996	Included

All

Female
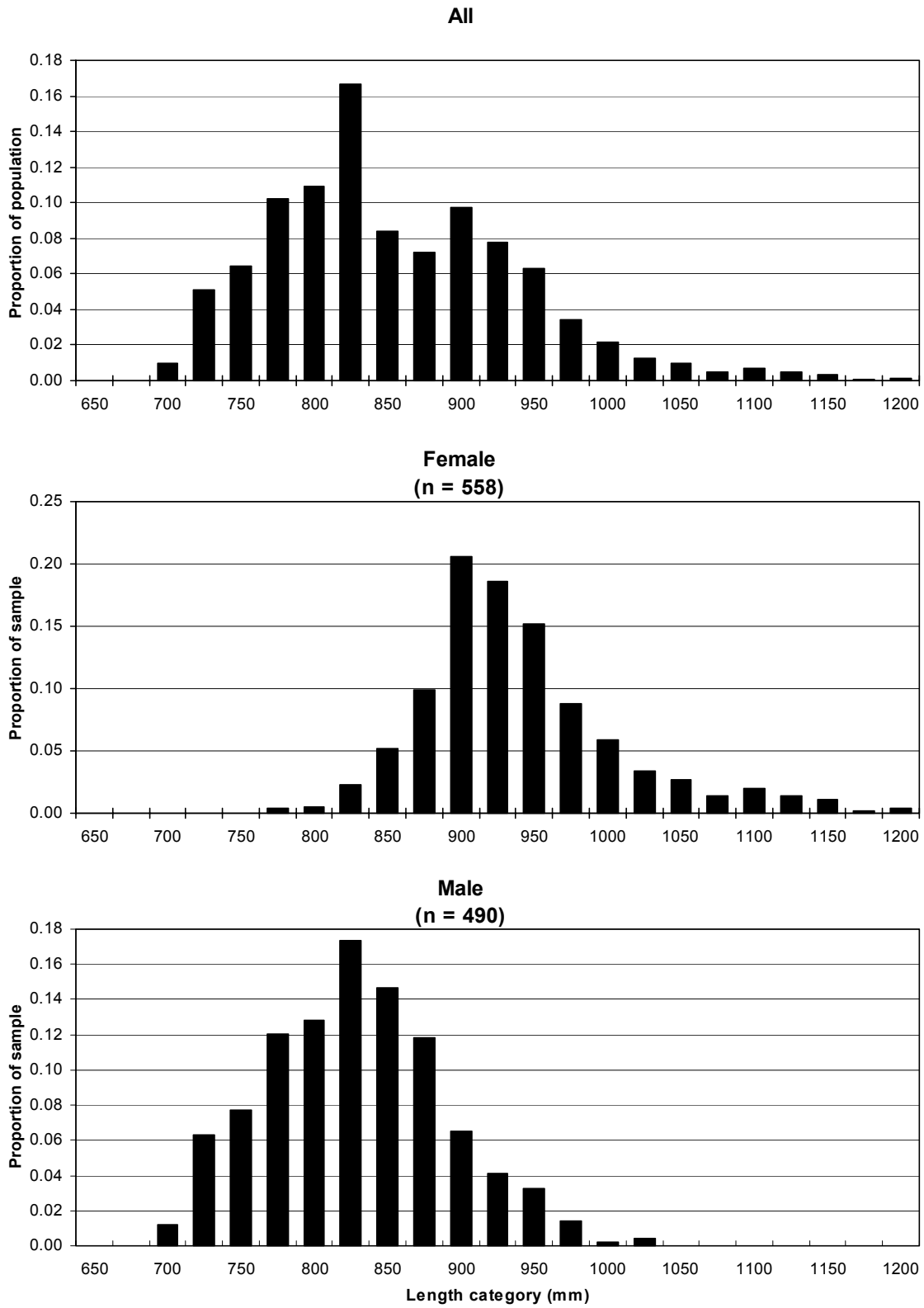## (n = 558)

Male
(n = 490)

Figure 3.-Length composition of sheefish examined from the Kobuk River during sampling in 1996.
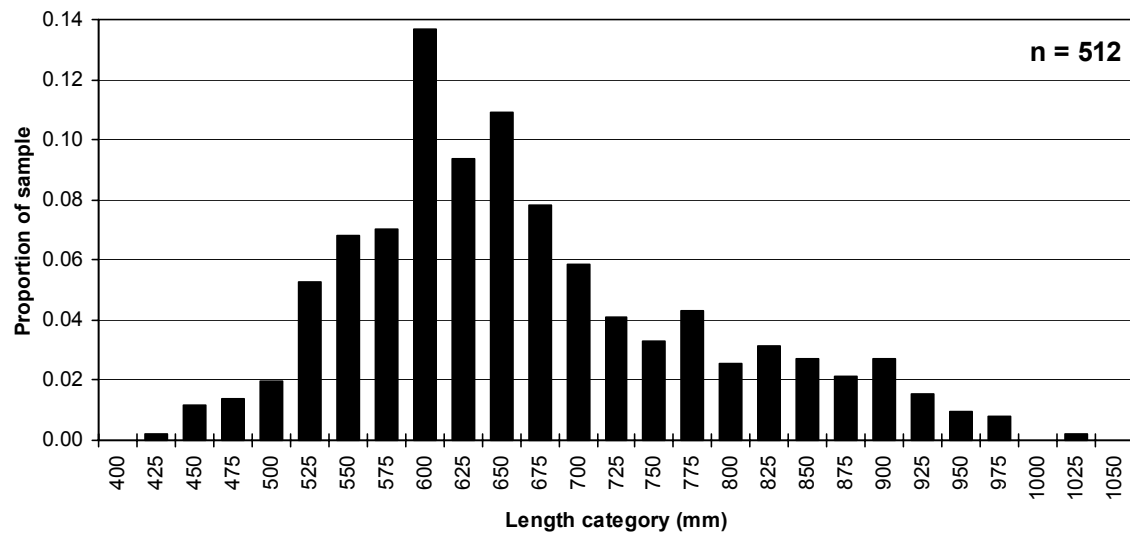
Figure 4.-Length composition of sheefish examined from Hotham Inlet hooking fishery during sampling in 1996.